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Dual-Energy CT in the Detection of Bone Marrow Edema in the Sacroiliac Joints: Is There a Case for Axial Spondyloarthritis?

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Conflicts of interest are listed at the end of this article.

See also the article by Wu et al in this issue.

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Diagnosis and management of axial spondyloarthritis largely depends on identification of inflammatory activity and structural changes of the axial skeleton, with the sacroiliac joints being affected most often. Structural changes can usually be detected with plain radiography as a first-line imaging modality. However, because of inherent limitations such as the superposition of abdominal viscera, limited sensitivity and specificity must be expected (1).

MRI depicts both subchondral bone marrow edema as an early indicator of inflammatory disease activity and structural changes of bone erosions, new bone formation, sclerosis, and fatty infiltration. Thus, MRI has shifted diagnosis and disease monitoring of axial spondyloarthritis to an earlier preradiographic stage (2). Although structural changes in the sacroiliac joint may be considered supportive findings for the diagnosis of sacroiliitis, bone marrow edema is required to correctly diagnose active sacroiliitis. Nevertheless, subtle bone erosions and productive bone changes are better seen at CT (1). European League Against Rheumatism (or EULAR) criteria state that CT is to be used if conventional radiographic findings are negative and MRI cannot be performed (2).

In this issue of *Radiology*, Wu and colleagues investigated a virtual noncalcium technique with dual-energy CT in the detection and grading of subchondral bone marrow edema of the iliac bone in patients with axial spondyloarthritis (3). It therefore challenges the role of MRI as the sole imaging modality with which to identify bone marrow edema.

A total of 47 consecutive study participants with a diagnosis of axial spondyloarthritis were prospectively included in this study. Dual-energy CT was performed within 24 hours after MRI. Low 80-kVp and tin-filtered high 140-kVp tube voltage data sets were obtained. Virtual noncalcium images were generated based on a three-material decomposition algorithm (bone mineral, red, and fat bone marrow). Virtual noncalcium images were displayed as color-coded overlay maps merged with weighted-average CT images and visually graded by two experienced musculoskeletal radiologists. In addition, quantitative CT numbers were measured at virtual noncalcium CT in iliac bone regions. Authors found substantial interreader agreement for lesion grading based on qualitative virtual noncalcium scores, indicating high reproducibility. Sensitivity and specificity were between 87%–93% and 91%–94% for qualitative bone marrow edema detection, respectively. In addition, quantitative attenuation values of regions affected with bone marrow edema increased with increasing bone marrow edema severity. At −35 HU, sensitivity and specificity for bone marrow edema ranged between 90%–94% and 80%–83%, respectively.

Bone marrow edema is heterogeneous in etiology (4). It is generally considered as an invasion of fatty bone marrow by an inflammatory infiltrate leading to local osteopenia and vascular leakage with locally increased water content (5). Change in bone marrow composition is reflected by high signal intensity on T2-weighted, fat-saturated MR images. The corresponding increased attenuation at CT adds to the notion of increasing water content in an otherwise fatty environment. Water content can be detected by changes in tissue MR relaxation time or changes in x-ray attenuation behavior, as in this current study.

It is not surprising that bone marrow edema scores from virtual noncalcium dual-energy CT do not entirely correspond to standard MRI scores. Fatty infiltration of bone marrow may decrease cutoff attenuation thresholds for quantitative bone marrow edema detection, as is the case in postinflammatory as well as physiologic bone marrow changes due to aging. In addition, osteoporosis and radiation therapy may also increase fat content of bone marrow. On the other hand, chronic inflammatory or lymphoproliferative disorders may increase red marrow cellularity and density of bone marrow; this may also complicate quantitative attenuation–based identification of bone marrow edema on virtual noncalcium images.

Furthermore, the ideal cutoff attenuation values for bone marrow edema likely depend on tube energies and postprocessing settings. In addition, bone marrow composition changes with anatomic location, as shown in a similar study on posttraumatic bone marrow edema of the ankle joint (6). In this respect, it is important to note that bone marrow edema was only assessed in the iliac bone in this study. From my own experience, minimal bone marrow edema may sometimes only be seen on the sacral side of sacroiliac joints. In that case, the virtual noncalcium presets may have to be adjusted for best diagnostic performance.

The authors excluded sacroiliac joints with severe sclerosis. This is because subtle bone marrow edema adjacent to sclerotic voxels gets easily masked by spatial averaging. Similar exclusion criteria have been applied in other virtual noncalcium CT studies on posttraumatic bone marrow edema (6,7), narrowing the investigated spectrum of bone marrow edema to rather large areas with higher intensity scores. However, often subtle changes in the subchondral bone marrow must be considered, challenging the applicability of this technique.

In conclusion, this study shows that bone marrow edema from rheumatic sacroiliitis in patients with axial spondyloarthritis can be identified by using dual-energy CT with high accuracy. The door appears to be open for further studies tackling the value of this method, in combination with the already high value of CT in assessing concomitant structural changes of sacroiliac joints.

Disclosures of Conflicts of Interest: R.G. disclosed no relevant relationships.

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